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FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME II

Session 6 - Environmental Systems: Management and Optimisation

Session 7 - New Methods and Technologies for Medicine and Biology

Session 8 - Embedded System Design and Application

Session 9 - Image Processing, Image Analysis and Computer Vision

Session 10 - Mobile Communications

Session 11 - Education in Computer Science and Automation

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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Nadir Z. Khan / M. A. A. Kalil / K. Ghanem / A. Mitschele-Thiel

Generic Autonomic Architecture for Self-Management in Future Heterogeneous Networks

ABSTRACT

Nowadays, self-management capabilites, in any system, are provided by developing some independent modules. The modules performs different targeted operations. As the element of heterogenity will increase in future networks, the interactions among these modules will become complexer and will be harder to manage. Thus the autonomity in the system will decrease. We proposed a generic five layered architecture which focuses in increased self-management capabilites for heterogeneous networks. This paper presents the idea of a generic five layered architecture for self-management in heterogeneous networks with an overview of interactions and interfaces.

INTRODUCTION

Self-management capabilities are considered very essential for large heterogeneous telecommunication networks. A common practical approach is to provide different self-management capabilities with the help of one or more external modules. Usually these modules are developed having certain targets, in mind, for specific requirements. Usual targets of these modules are to monitor a specific system behavior, adapt to changes at run time, to configure the system, to improve performance or to recover from different faults. It is obvious that the combination of different modules, working together with each other, will increase as the heterogeneity in the telecommunication system will increase. Sometimes, it is desired to integrate different modules in a telecommunication system either in order to increase performance of the combined modules or to have new functionalities in the management system of the heterogeneous network. Since the combination of the modules increases with the number of desired functions, obviously the extent of autonomity in the management system of any heterogeneous network will decrease. That means, the automatic functions in management system will be more complex and difficult. Firstly, without any generic architecture of management system for heterogeneous system it would nearly be impossible for all the independent modules to work in an integrated way. Secondly, if in any case it becomes possible it would be only due to a large number of different types of independent interfaces among different modules.

RELATED WORK

Different architectures have been proposed to develop specific self-management functionalities in networks. In [1], policy based management architecture is developed. This architecture is related to solving complex issues with the help of integrated mechanism of knowledge-based reasoning and business policies. The work, in [2], is to have better co-ordination for global configuration and fault repairing. This work is focusing on the self-management video conferencing system. This work is not a solution for a generic architecture of autonomic self management system. Authors in [3], [4] proposed autonomic service architectures ensuring the service level agreements. In [3], a layered architecture is proposed for autonomic networks. These two proposed architecture are not talking about the issues of reducing complexity in integration of independent management modules. The work, in [5], have described some design pattern and recommended some interaction towards an autonomic architecture.

FIVE LAYER ARCHITECTURE

To have a proper way to achieve autonomity in management of any heterogeneous system, we realized the need of defining a generic architecture for management of any heterogeneous system. We proposed a layered architectural approach to have efficient integration of different self-management modules in heterogeneous networks. This architecture focuses on the theories and architectural definition of behavioral requirements for self-management components in heterogeneous networks. It discusses the minimum interactions among components and recommends design patterns to introduce system-level properties of self-configuration, self-optimization, self-healing and self-protection.

The main objective is to define an architecture which introduces the dynamic re-configurability in the future network elements as well as the capability to share and distribute the services between the different providers. The automation of services management has a significant importance in the future management systems. Thus the proposed generic architecture is designed to provide the capabilities to get a dynamic, reusable, scalable and reliable infrastructure that can integrate with the existing systems too.

The proposed architecture is divided in different logical layers according to their purposes and functions. It is a two dimensional layered architecture. The architecture is composed of four horizontal layers and a single vertical layer.

Vertical Logical Layer

In figure 1, ***System Layer*** is vertically placed in the architecture. It represents different global objectives of the network systems, for example service authorization & access management, configuration management, fault management, security management, performance management, bandwidth management, and accounting management. Each management system can have a lot of processes, information flow mechanisms, resources and services to carry on the specific management tasks. To perform the management of a network system, the vertical layer can have some sub-systems that may include systems like monitoring systems, security systems, network administration systems, resource management systems. Each system at the vertical layer will have a lot of elements that are categorized in different horizontal layers. The elements in horizontal layer combine together to make up a system that is represented in the vertical layer.

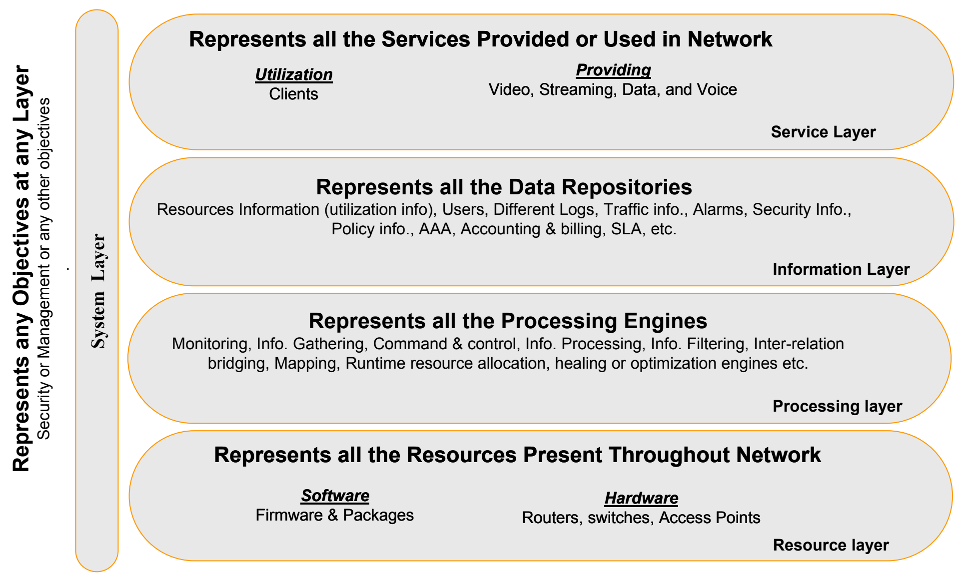

Figure 1: Logical view of different layers in generic autonomic architecture for self-management in future heterogeneous networks

Horizental Logical Layers

The horizontal logical layers are viewed logically in any system. The idea is to introduce the flexibility by logically dividing all the elements for future network systems. This is the key to enable flexible integration of different modules in any system. ***Service Layer*** is divided into service provisioning and service utilization. This layer differentiates into service provider and service utilization entities. Service provisioning could include video, audio, data or any composite service. ***Information Layer*** represents the knowledge base of the system. In simple words it is the data resource of all the system. This layer distributes all information among the system such as policy information, authentications, accounting and billing, SLA, security alerts, and alarms.

Processing Layer deals with all the processes and engines that make a system. This layer represents any process that is present in the system as a separate and integrable entity. This can for example include the monitoring engine, the command & control interface, and the resource allocation interface. ***Resources Layer*** is further divided into hardware and software resources. The software resource could be firmware or any software package that is being utilized or might be needed by any other piece of software and hardware or by any service providing elements. Hardware represents any resources that are present in the network system such as access points, routers, and switches. In order to have autonomous capability in the system the resources, that might be a software and hardware resource, are divided into different categories according to their ability and functionality.

Categorization of Resources

Different resources (i.e. hardware or software) are divided, into different catagories, according to their ability and functionalities. A resource is categorized as Cat-0A assuming it has very less negotiation power and a dedicated information delivery. A resource belongs to the Cat-1A category when it has reconfigurable service capability, by changing firmware or what so ever. However it will lack for good coordination capabilities with different resources. A Cat-1B categorized resource is supposed to be a resource that could be reconfigurable and would have strong coordination and collaboration capabilities. The highest category, considered so far, Cat-1C is considered as a powerful resource with good storage and processing capabilities. It can provide multiple reconfigurable services at a time. It also may act as a leader and information source for similar and for lower categorized resources. The table1 summarizes the categories described above.

Table1: The categorization of resources

Resource Category	Capabilities and Functionalities
Cat-0A	Dedicated Information delivery and Limited Negotiations
Cat-1A	Reconfigurable Service. One at a time. Less Co-ordination Capability.
Cat-1B	Strong Co-ordination & Collaborative Capabilities
Cat-1C	Reconfigurable Multi-Services at a time. In case of hardware resource: Can share firmware. Can be acting as a source too.
….	….
Cat-xx	Categories to be used in future.

Interactions & Interfaces Among Different Layers

The interactions among different layers are considered in order to clarify the required interfaces among different layers. Figure 2, shows the alternate view of logical architecture. All the autonomous management system is shown at the top of vertical System layer in figure 2. Different horizontal layers are lying over it. System Layer has

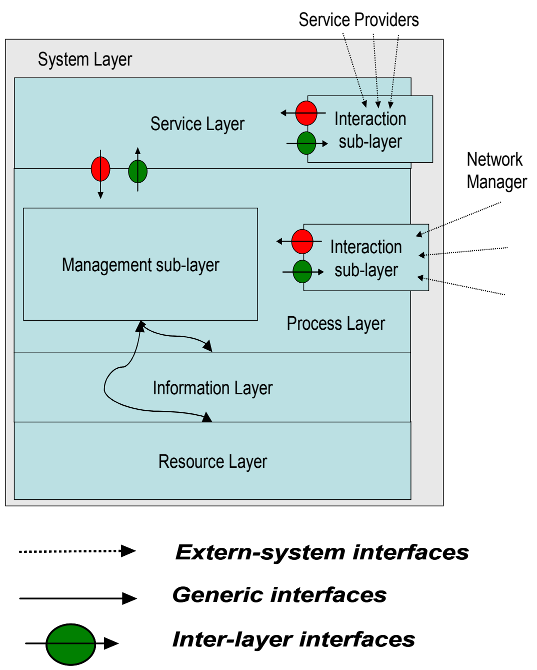

Figure 2: Alternative views of logical layers with interactions among different layers.

direct interactions to all other layer. The Process Layer transforms the decisions and information of the management sub-layer into instructions understandable by the Resource Layer. The Process Layer will have dedicated processes related to management and managers interaction sub-layer. So different processes performing management, interactions or security tasks, may lie on Process Layer.

There are three different types of interfaces. One type is used to provide the interaction between the system with external entities such as service providers or network manager. These are called ***extern-system interfaces***. Second types of interfaces are shown with circle and an arrow head. These interfaces are inter-layer interfaces. These are used as internal interfaces to provide special features along with the interaction between different layers. For example, ***inter-layer interfaces*** can provide secure transactions of information among different layers making sure that only the concern processes and resources are involved even within the same system that has several others non-concern processes and resources. The third type of interfaces are rather involved in normal interactions among different layers.

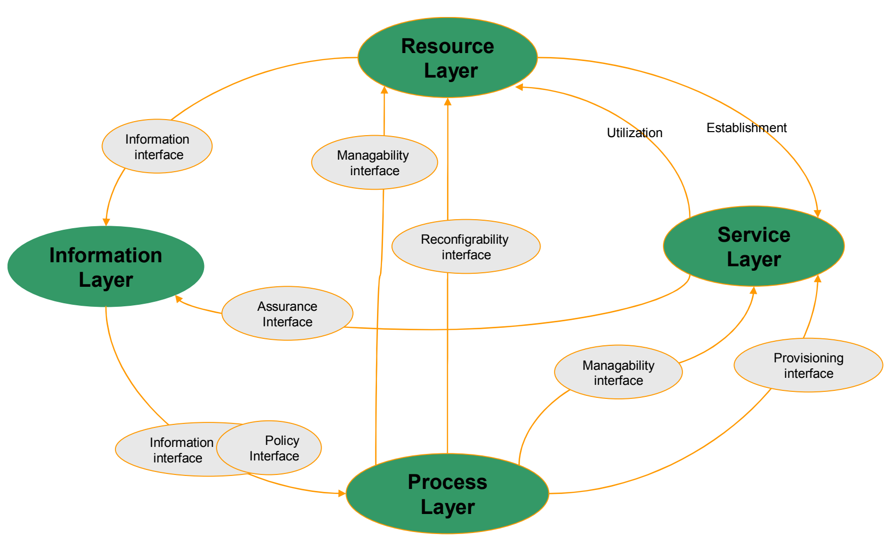

Figure 3: Example of possible interfaces and work flow among logical layers

In figure 3, different possible interactions with required interfaces in shown. In a self-management system resource will send some information to the information base. At the same time different processes at Process Layer will process the data from Information Layer such as policies and information to manage and provide different services at the Service Layer. Also Process Layer will use information from Information Layer to reconfigure and manage the resources according to defined policies. The reconfigured resources at the resource layer will establish different services at the Service Layer. Service Layer will provide information in order to ensure the service level agreements.

Summary and Conclusion

In this paper, we introduced the generic five layered architecture for future heterogeneous netowrks which is focused to enable the development of systems with autonomous self-management capabiliteis. The presented architecture is divided into one vertical layer and four horizental layers. A prototype of a future management system with different modules applications is developed according to core idea of this architecture. Many advantages such as increased flexibility, availability and mobility. have been observed during the development of these applications and modules. A complex future management system for heterogeneous network, with the idea of proposed architecture, is under development. In future, the benefits and weakness of developed systems with other system will be observed and compared.

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Authors:
Mr. Nadir Zamin Khan
Mr. Mohamed Abdrabou
Mr. Kinan Ghanem
Prof. Andreas Mitschele-Thiel
Technical University of Ilmenau
Faculty of computer science and automation
Integrated Hardware and Software Systems Group
D-98693 Ilmenau
Phone: +49 (0)3677 69 1696
Fax: +49 (0)3677 69 1220
E-mail: { nadir.zamin-khan/ Kinan.Ghanem/ mohamed.abdrabou/ Mitsch}@tu-ilmenau.de